CLAIMS

What is claimed is:

1. An electrochemical device, comprising:

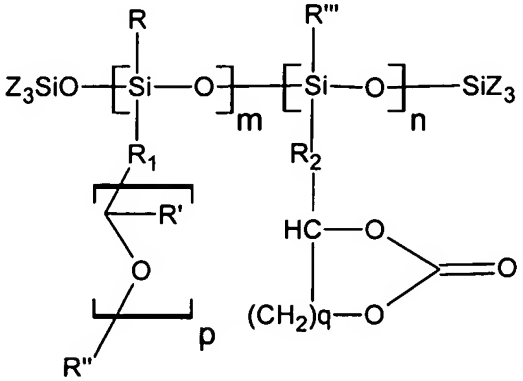
a liquid electrolyte including a polysiloxane having one or more backbone silicons linked to a first side chain and one or more backbone silicons linked to a second side chain, the first side chains including a poly(alkylene oxide) moiety and the second side chains including a cyclic carbonate moiety.

2. The device of claim 1, wherein each of the non-terminal silicons in the backbone of the polysiloxane are linked to at least one side chain selected from a group consisting of a first side chain and a second side chain.

3. The device of claim 1, wherein the polysiloxane excludes Si-H groups.

4. The device of claim 1, wherein the first side chains include a first spacer positioned between the poly(alkylene oxide) moiety and the backbone of the polysiloxane and the second side chains include a second spacer positioned between the cyclic carbonate moiety and the backbone of the polysiloxane, the first spacer including one or more CH_2 groups and the second spacer including one or more CH_2 groups.

5. The device of claim 1, wherein the polysiloxane has a structure according to General Formula I:



where R is an alkyl group; R' is hydrogen or an alkyl group; R" is an alkyl group; R''' is alkyl; R_1 is an alkylene, alkylene oxide or bivalent

ether moiety; R_2 is an alkylene, alkylene oxide or bivalent ether moiety; m is greater than or equal to 1 and n is greater than or equal to 1; p is 3 to 20; q is 1 to 2; and Z is an alkyl or aryl group.

6. The device of claim 1, wherein the average molecular weight for the polysiloxane is less than or equal to 4000 g/mole.

7. The device of claim 1, wherein the electrolyte includes lithium ions and wherein a [EO]/[Li] ratio is 5 to 50, [EO] being the molar concentration of the active oxygens in the electrolyte and [Li] being the molar concentration of the lithium ions in the electrolyte.

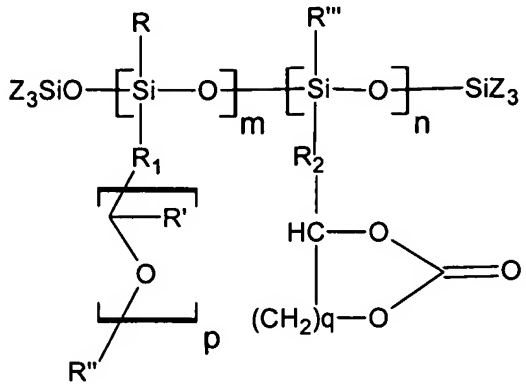
8. An electrochemical device, comprising:

an electrolyte including a polysiloxane, each of the non-terminal silicons in the backbone of the polysiloxane being linked to at least one entity selected from a group consisting of: first side chains that include a poly(alkylene oxide) moiety and second side chains that include a cyclic carbonate moiety.

9. The device of claim 8, wherein the polysiloxane excludes Si-H groups.

10. The device of claim 8, wherein the first side chains include a first spacer positioned between the poly(alkylene oxide) moiety and the backbone of the polysiloxane and the second side chains include a second spacer positioned between the cyclic carbonate moiety and the backbone of the polysiloxane, the first spacer including one or more CH_2 groups and the second spacer including one or more CH_2 groups.

11. The device of claim 8, wherein the polysiloxane has a structure according to General Formula I:



where R is an alkyl group; R' is hydrogen or an alkyl group; R" is an alkyl group; R''' is alkyl; R_1 is an alkylene, alkylene oxide or bivalent ether moiety; R_2 is an alkylene, alkylene oxide or bivalent ether moiety; m is greater than or equal to 1; n is greater than or equal to 1; p is 3 to 20; q is 1 to 2; and Z is an alkyl or aryl group.

12. The device of claim 8, wherein the average molecular weight for the polysiloxane is less than or equal to 4000 g/mole.

13. The device of claim 8, wherein the electrolyte includes lithium ions and wherein a [EO]/[Li] ratio is 5 to 50, [EO] being the molar concentration of the active oxygens in the electrolyte and [Li] being the molar concentration of the lithium ions in the electrolyte.

14. A precursor solution for use in generating a polysiloxane, comprising:

a polysiloxane precursor wherein each of the non-terminal backbone silicons is member of at least one Si-H group, a first side-chain precursor including a poly(alkylene oxide) moiety and being allyl terminated, and a second side-chain precursor including a cyclic carbonate moiety and being allyl terminated; and

the polysiloxane precursor, the first side-chain precursor and the second side-chain precursor present in the solution so as to provide the solution with a ratio, [SC]/[Si-H], greater than 1:1, [SC]/[Si-H] being the ratio of (the molar concentration of the first side-chain precursor in the solution + the molar concentration of the second side-chain precursor in the solution) : (the molar concentration of the Si-H groups on backbone of the polysiloxane precursor in the solution).

15. The solution of claim 14, wherein [SC]/[Si-H] is greater than 1.1:1.

16. The solution of claim 14, wherein [SC]/[Si-H] is less than 3:1.

17. The solution of claim 14, wherein the first side-chain precursor and the second side-chain precursor are present in the solution at concentrations that provide a side-chain precursor ratio greater than 1:1, the side-chain precursor ratio being the ratio of the molar concentration of the second side-chain precursor to the molar concentration of the first side-chain precursor.

18. The solution of claim 17, the side-chain precursor ratio is less than 1:20.

19. The solution of claim 14, further comprising:
a platinum catalyst.

20. A method of forming an electrolyte that is suitable for use in an electrochemical device, comprising:

generating a precursor solution that includes a polysiloxane precursor where each of the non-terminal backbone silicons is member of at least one Si-H group, a first side-chain precursor including a poly(alkylene oxide) moiety and being allyl terminated, and a second side-chain precursor including a cyclic carbonate moiety and being allyl terminated; the components being mixed so as to provide a ratio, [SC]/[Si-H], greater than 1:1, [SC]/[Si-H] being the ratio of (the molar concentration of the first side-chain precursor in the solution + the molar concentration of the second side-chain precursor in the solution) : (the molar concentration of the Si-H groups on backbone of the polysiloxane precursor in the solution).

21. The method of claim 20, wherein the components are mixed so as to provide [SC]/[Si-H] greater than 1.1:1.

22. The method of claim 20, wherein the components are mixed so as to provide [SC]/[Si-H] greater than 3:1.

23. The method of claim 20, wherein the components are mixed so as to provide a side-chain precursor ratio greater than 1:1, the side-chain precursor ratio being the ratio of the molar concentration of the second side-chain precursor to the molar concentration of the first side-chain precursor.

24. The method of claim 23, wherein the components are mixed so as to provide a side-chain precursor ratio less than 1:20.

25. The method of claim 20, further comprising:

reacting the components of the precursor solution so as to form a product solution that includes a polysiloxane having one or more backbone silicons linked to a first side chain and one or more backbone silicons linked to a second side chain, the first side chains including a poly(alkylene oxide) moiety and the second side chains including a cyclic carbonate moiety.

26. The method of claim 25, further comprising:

removing one or more components from the product solution, the one or more components including at least one component selected from the group consisting of: first side-chain precursor remaining in the product solution and second side-chain precursor remaining in the product solution.

27. The method of claim 26, further comprising:

dissolving a salt in the product solution after removing the one or more components.

28. An electrochemical device, comprising:

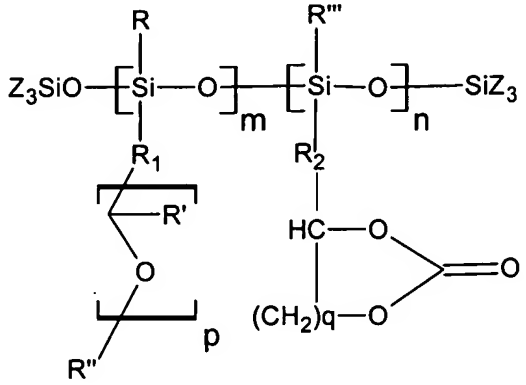
an electrolyte including

a polysiloxane having one or more backbone silicons linked to a first side chain and one or more backbone silicons linked to a second side chain, the first side chains including a poly(alkylene oxide) moiety and the second side chains including a cyclic carbonate moiety, and

a cross-linked network polymer having interstices in which the polysiloxane is positioned.

29. The device of claim 28, wherein the first side chains include a first spacer positioned between the poly(alkylene oxide) moiety and the backbone of the polysiloxane and the second side chains include a second spacer positioned between the cyclic carbonate moiety and the backbone of the polysiloxane, the first spacer including one or more CH_2 groups and the second spacer including one or more CH_2 groups.

30. The device of claim 29, wherein the polysiloxane has a structure according to General Formula I:



where R is an alkyl group; R' is hydrogen or an alkyl group; R" is an alkyl group; R''' is alkyl; R_1 is an alkylene, alkylene oxide or bivalent ether moiety; R_2 is an alkylene, alkylene oxide or bivalent ether moiety; m is greater than or equal to 1; n is greater than or equal to 1; p is 3 to 20; q is 1 to 2; and Z is an alkyl or aryl group.

31. The device of claim 28, wherein the average molecular weight for the polysiloxane is less than or equal to 4000 g/mole.

32. The device of claim 28, wherein the electrolyte includes lithium ions and wherein a [EO]/[Li] ratio is 5 to 50, [EO] being the molar concentration of the active oxygens in the electrolyte and [Li] being the molar concentration of the lithium ions in the electrolyte.

33. The device of claim 28, wherein the electrolyte is a solid.

34. The device of claim 28, wherein the electrolyte is a gel.

35. The device of claim 28, wherein the network polymer interacts with the polysiloxane so as to form an interpenetrating network.

36. The device of claim 28, wherein the network polymer includes a polyacrylate or a polymethacrylate.

37. The device of claim 28, wherein the network polymer is a polymer of a dialkyl acrylate, a dimethacrylate, a diallyl terminated compound or a dialkyl methacrylate.

38. A method of generating an electrochemical device, comprising:

generating an electrolyte that includes

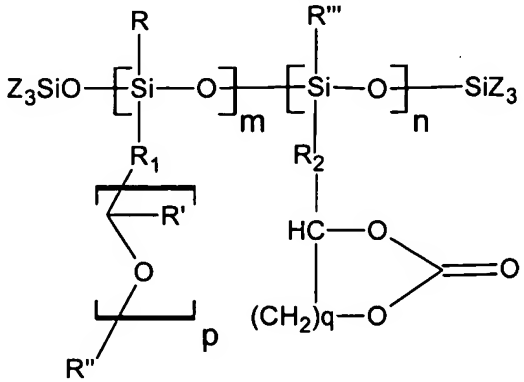
a polysiloxane having one or more backbone silicons linked to a first side chain and one or more backbone silicons linked to a second side chain, the first side chains including a poly(alkylene oxide) moiety and the second side chains including a cyclic carbonate moiety, and

a cross-linked network polymer having interstices in which the polysiloxane is positioned; and

activating one or more electrodes and one or more anodes with the electrolyte.

39. The method of claim 38, wherein the first side chains include a first spacer positioned between the poly(alkylene oxide) moiety and the backbone of the polysiloxane and the second side chains include a second spacer positioned between the cyclic carbonate moiety and the backbone of the polysiloxane, the first spacer including one or more CH_2 groups and the second spacer including one or more CH_2 groups.

40. The method of claim 38, wherein the polysiloxane has a structure according to General Formula I:



where R is an alkyl group; R' is hydrogen or an alkyl group; R" is an alkyl group; R''' is alkyl; R_1 is an alkylene, alkylene oxide or bivalent

ether moiety; R_2 is an alkylene, alkylene oxide or bivalent ether moiety; m is greater than or equal to 1; n is greater than or equal to 1; p is 3 to 20; q is 1 to 2; and Z is an alkyl or aryl group.

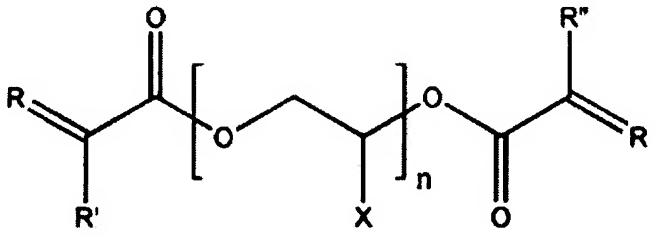
41. The method of claim 38, wherein the average molecular weight for the polysiloxane is less than or equal to 4000 g/mole.

42. The method of claim 38, wherein the electrolyte includes lithium ions and wherein a [EO]/[Li] ratio is 5 to 50, [EO] being the molar concentration of the active oxygens in the electrolyte and [Li] being the molar concentration of the lithium ions in the electrolyte.

43. The method of claim 38, wherein generating the electrolyte includes forming a precursor solution that includes the polysiloxane and monomers for forming the cross-linked network polymer.

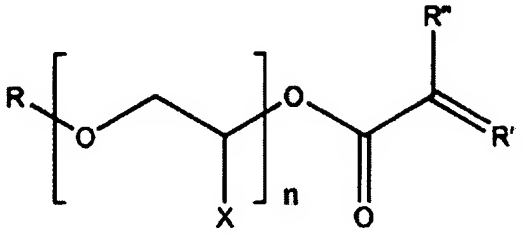
44. The method of claim 43, wherein the precursor solution includes a radical initiator.

45. The method of claim 43, wherein one or more of the monomers are selected from a group consisting of: a dialkyl acrylate, a dimethacrylate, a diallyl terminated compound or a dialkyl methacrylate.

46. The method of claim 43, wherein one or more of the monomers has a structure according to Formula IV: 

wherein R is an alkyl group having 1 to 10 carbon atoms; R' is a hydrogen or an alkyl group having 1 to 10 carbon atoms or an alkenyl group having 2 to 12 carbon atoms; R" is a hydrogen or an alkyl group having 1 to 10 carbon atoms or an alkenyl group having 2 to 12 carbon atoms; X is hydrogen or a methyl group; and n represents a numeral of 1 to 15.

47. The method of claim 43, wherein the precursor solution includes a control monomer for controlling cross-linking density.

48. The method of claim 47, wherein the control monomer has a structure according to Formula V:  where R is an alkyl group having 1 to 10 carbon atoms, R' is an alkyl group having 1 to 10 carbon atoms; R" is hydrogen or a group selected from an alkyl group having 1 to 10 carbon atoms and/or an alkenyl group having 2 to 12 carbon atoms; X is hydrogen or a methyl group; and n represents a whole number from 1 to 20.

49. An electrochemical device, comprising:

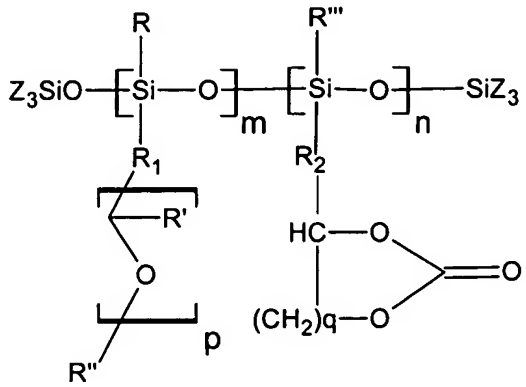
a liquid electrolyte including

a polysiloxane having one or more backbone silicons linked to a first side chain and one or more backbone silicons linked to a second side chain, the first side chains including a poly(alkylene oxide) moiety and the second side chains including a cyclic carbonate moiety, and

a solid polymer, the solid polymer being a solid at room temperature when standing alone.

50. The device of claim 49, wherein the first side chains include a first spacer positioned between the poly(alkylene oxide) moiety and the backbone of the polysiloxane and the second side chains include a second spacer positioned between the cyclic carbonate moiety and the backbone of the polysiloxane, the first spacer including one or more CH_2 groups and the second spacer including one or more CH_2 groups.

51. The device of claim 49, wherein the polysiloxane has a structure according to General Formula I:



where R is an alkyl group; R' is hydrogen or an alkyl group; R" is an alkyl group; R''' is alkyl; R_1 is an alkylene, alkylene oxide or bivalent ether moiety; R_2 is an alkylene, alkylene oxide or bivalent ether moiety; m is greater than or equal to 1; n is greater than or equal to 1; p is 3 to 20; q is 1 to 2; and Z is an alkyl or aryl group.

52. The device of claim 49, wherein the average molecular weight for the polysiloxane is less than or equal to 4000 g/mole.

53. The device of claim 49, wherein the electrolyte includes lithium ions and wherein a [EO]/[Li] ratio is 5 to 50, [EO] being the molar concentration of the active oxygens in the electrolyte and [Li] being the molar concentration of the lithium ions in the electrolyte.

54. The device of claim 49, wherein the solid polymer includes one or more components selected from the group consisting of: polyacrylonitrile (PAN), poly(methyl methacrylate) (PMMA), poly(vinylidene fluoride) (PVDF), poly(vinylidene fluoride-co-hexafluoropropylene), polystyrene, polyvinyl chloride, poly(alkyl methacrylate), poly(alkyl acrylate), styrene butadiene rubber (SBR), poly(vinyl acetate) and poly(ethylene oxide) (PEO).

55. A method of forming an electrochemical device, comprising:

generating an electrolyte that includes

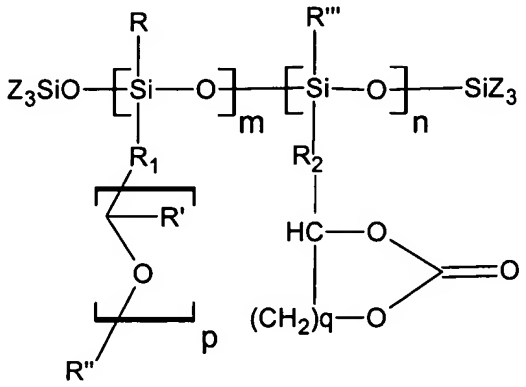
a polysiloxane having one or more backbone silicons linked to a first side chain and one or more backbone silicons linked to a second side chain, the first side chains including a poly(alkylene oxide) moiety and the second side chains including a cyclic carbonate moiety, and

a cross-linked network polymer having interstices in which the polysiloxane is positioned; and

a solid polymer, the solid polymer being a solid at room temperature when standing alone.

56. The method of claim 55, wherein the first side chains include a first spacer positioned between the poly(alkylene oxide) moiety and the backbone of the polysiloxane and the second side chains include a second spacer positioned between the cyclic carbonate moiety and the backbone of the polysiloxane, the first spacer including one or more CH_2 groups and the second spacer including one or more CH_2 groups.

57. The method of claim 55, wherein the polysiloxane has a structure according to General Formula I:



where R is an alkyl group; R' is hydrogen or an alkyl group; R" is an alkyl group; R''' is alkyl; R_1 is an alkylene, alkylene oxide or bivalent ether moiety; R_2 is an alkylene, alkylene oxide or bivalent ether moiety; m is greater than or equal to 1; n is greater than or equal to 1; p is 3 to 20; q is 1 to 2; and Z is an alkyl or aryl group.

58. The method of claim 55, wherein the average molecular weight for the polysiloxane is less than or equal to 4000 g/mole.

59. The method of claim 55, wherein the electrolyte includes lithium ions and wherein a [EO]/[Li] ratio is 5 to 50, [EO] being the molar concentration of the active oxygens in the electrolyte and [Li] being the molar concentration of the lithium ions in the electrolyte.

60. The method of claim 55, wherein the solid polymer includes one or more components selected from the group consisting of: polyacrylonitrile (PAN), poly(methyl methacrylate) (PMMA), poly(vinylidene fluoride) (PVDF), poly(vinylidene fluoride-co-hexafluoropropylene), polystyrene, polyvinyl chloride, poly(alkyl methacrylate), poly(alkyl acrylate), styrene butadiene rubber (SBR), poly(vinyl acetate) and poly(ethylene oxide) (PEO).

61. The method of claim 55, wherein generating the electrolyte includes generating a precursor solution that includes the polysiloxane and the solid polymer.

62. The method of claim 61, wherein generating the precursor solution includes mixing the polysiloxane and a solution that includes the solid polymer dissolved in a solvent.

63. The method of claim 62, wherein generating the precursor solution includes evaporating the solvent from the precursor solution.

64. The method of claim 61, wherein generating the precursor solution includes mixing the polysiloxane and monomers for the solid polymer.

65. The method of claim 64, wherein generating the precursor solution includes polymerizing the monomer.